

Enrichment of meat products with dietary fibers: a review

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Abstract. In recent years, much attention has been paid to the development of food products with properties that can promote well-being and prevent disease. Tested strategies to improve the functional value of meat products through the introduction of dietary fiber are reviewed here. Based on the literature reviewed, the addition of dietary fiber in meat products contributes to the fabrication of products which enhance physiological functions. Furthermore, fibers can be used to improve the quality and yield of meat products.

Key words: dietary fiber, meat product, health, functional value.

INTRODUCTION

The meat industry is one of the most important in the world. One of the directions, for the development of the meat industry, is the production of healthy foods characterized by a lower fat content. This development also includes the enhancement of meat products to achieve a higher content in minerals, vitamins, antioxidants or dietary fibers (Cofrades et al., 2008; Zhang et al., 2010; Bis-Souza et al., 2018).

Dietary fibers are recognized to have an important physiological role in the human body. For this reason, dietary fibers are considered before other nutrients to ensure a healthy nutrition. The lack of fibers in the diet is often associated with gastrointestinal diseases, including constipation, colon cancer; increased risks of cardiovascular diseases, including hypercholesterolemia, stroke, and ischemic heart; metabolic diseases, including obesity and diabetes (Jimenez-Colmenero et al., 2001; Fuller et al., 2016).

The fat content significantly affects organoleptic characteristics of meat products. This is because fat has binding properties and contribute to juiciness, tenderness and taste (Mallika et al., 2009). For example, in sausages, it was noted that a low fat content reduces the taste and texture qualities of foods (Choi et al., 2011). Various dietary fibers have, therefore, been used to improve the texture of meat products with a low fat content

(Pintado et al., 2016). The addition of dietary fibers was shown to improve texture properties by Schmiele et al. (2015) and Bis-Souza et al. (2018). Replacing fats with dietary fibers contributes to lowering the calorie content of meat products (Hu et al., 2015).

The recent increased consumer interest in healthy and low fat nutrition, opens the door to the development of a large market for fiber-rich foods. The purpose of this study is to review the actual information on dietary fibers application in the formulations of fortified meat products as well as analysis of their effects on technological properties of meat.

SPECIFICATION OF DIETARY FIBERS

Dietary fibers are generally known as the indigestible portion of food. In fact, the term ‘dietary fiber’ was first used in an article by Hipsley (1953). Trowell et al. (1985) defined dietary fiber as ‘the sum of polysaccharides and lignin not digested by the human gastrointestinal tract’. Later, Jimenez-Colmenero et al. (2001) defined dietary fibers as carbohydrate food components which are not hydrolyzed by the endogenous enzymes in the small intestine.

It is also known that diverse types of fibers have different properties within the gastro-intestinal track such that it is challenging to come up with a definition that encompasses all aspects. Zielinski & Rozema (2013) reviewed the definitions of ‘dietary fiber’, used by the Institute of Medicine, AACC International and Codex Alimentarius Commission and noted one commonality in these definitions: each mentioned positive physiological effects. This reflected that, in the international scientific community, the importance of dietary fibers in human nutrition was increasingly recognized.

Although the definition of dietary fibers is still elusive, Fuller et al. (2016) point to dietary fibers’ modes of action being related to chemical compounds defined by structure, or functional properties, and/or a combination of both structural and functional properties. The various classifications methodologies used to describe dietary fibers reflect such a complexity.

Different characteristics can be used as a basis for the classification of dietary fibers. The type of raw material, the structure of polymers, the amounts and proportions of raw materials and of co-agents, the ability to dissolve in water and water binding capacity can be used to classify dietary fiber. Other characteristics such as the ion exchange, sorption or physiological properties have also been used to classify dietary fibers. The most common classification strategies are described below.

USE OF DIETARY FIBERS IN MEAT PRODUCTS TECHNOLOGIES

Dietary fibers come from grains, vegetables, fruits, and enriched preparations of food products. Traditional sources of fibers and β -glucan in the diet are cereals, such as wheat, oats and barley (Sze et al., 2017). Fruits, vegetables, legumes, soy, psyllium husk and oat bran are good sources of SDF while whole grains are good sources of IDF (Fernandez-Gines et al., 2005). Preparations of cellulose are generally produced from wheat, rice, soybeans, citrus and bamboo. Pectin is extracted from citrus peels and apple pomace. Alginates are anionic polysaccharides isolated from marine algae (e.g. brown algae) or some bacteria. All of these are used in the preparation of meat products.

Oat products are of particular interest for many reasons. To start with, they tend to cost less than meat. In addition, they contain both SDF and IDF (Gramza-Michałowska et al., 2018). Oat fibers also have good water-absorption capacity and, as a result, they are often used in the production of emulsion-type products such as sausages, pâtés, as well as in minced meat products (like burgers). Finally, they enhance the flavor and texture of some meat products, like minced meat and pork sausages (García et al., 2002). It follows that oat flour (Serdaroglu, 2006), oat bran (Talukder & Sharma, 2010) and different preparations of oat fibers are used for the enrichment of an array of meat products.

Fruits are also an important source of dietary fiber. This source can also be cost effective because fruit fibers can be obtained as byproducts of the production of juices and other plant products. These fibers can be used alone or in combination with cereal fibers, in the formulation of meat products. Dietary fibers present in the skin of the fruit are considered functional ingredients in the formulation of meat products due to their water-holding capacity and low cooking loss (García et al., 2002). In this category, watermelon rind powder (WRP) is a rich source of dietary fibers and bioactive compounds that could be used in the development of functional foods. The high total dietary fiber content in the WRP indicates promises for food product enrichment applications to produce high-fiber, value-added, healthy foods (Naknaen et al., 2016).

Other interesting sources of dietary fibers are also chitin and chitosan. The chitin (polymer of β -(1,4)-linked 2-acetamido-2-deoxy-D-glucopyranose) is found mainly in the animal kingdom, it is structurally similar to cellulose (Kardas et al., 2012). Chitin is available from the shells of marine crustaceans such as crabs and shrimps; shells and skeletons of mollusks, krill, and insects as well as the cell walls of fungi (Kurita, 2006; Kardas et al., 2012; Cheung, 2013). Chitosan is a linear polysaccharide obtained by extensive, although not total, deacetylation of chitin. Chitin and chitosan are mainly composed of the random association of two kinds of β -1,4 linked structural units: 2-amino-2-deoxy-D-glucose and N-acetyl-2-amino-2-deoxy-D-glucose. Chitin and chitosan impose stability on food emulsions. The addition of chitin and chitosan to diets as a source of fibers has been deemed completely safe.

Dietary fibers are also found in the rhizomes of plants. Their high content in the lotus rhizome, chory root, Jerusalem artichoke is well known (Tomaschunas et al., 2013; Afoakwah et al., 2015; Ham et al., 2017).

Functional and technological effects of dietary fibers used in meat products

Dietary fibers have helpful functional properties which can enhance the quality and sensory characteristics of meat products. These functional properties depend on the types of dietary fiber incorporated to products. The most important functional properties of dietary fibers used in meat products are water-holding and fat-binding capacity, viscosity, gel-forming ability and emulsification properties (Kim & Paik, 2012). The water-holding capacity of dietary fibers is dependent on the structure, the chemical composition (Chau, 2003) and the relative proportions of different types of fibers. The addition of fibers to meat products can cause the following technological effects:

- 1) increase the moisture-retaining capacity of minced products,
- 2) improve the stability of emulsions,
- 3) substitute fat, reduce fat content,
- 4) increase the yield of the product,
- 5) improve the texture of meat products,

- 6) retain the shape of the product after heat treatment and
- 7) Stabilizes fats and proteins, which leads to increased storage stability.

When formulating meat products, the type of dietary fiber, chemical organization of the additive, and consumer properties of the enriched meat product must be taken into account. Different types of additions associated functional properties and concomitant technological effects are summarized in Table 1.

Applications of different additives in the technology of meat products

Most scientific analytical reviews of the applications of dietary fibers are based on the source of dietary fibers (cereals, vegetables, fruit, etc.). However, such a classification does not take into account how the dietary fiber additives were derived. Additives processing influences chemical composition. Thus, the impact of these additives on the properties of the product can also be different. For example, oat flour, oat bran and a purified preparation of dietary fiber from oat can present significant differences in the concentration of dietary fiber and other nutrients. Accordingly, the dosage of these additives, as well as how the additives were derived can influence the properties of the product. Consequently, the applications of different additives in the technology of meat products were reviewed for the three groups of sources of derived dietary fibers listed below:

- 1) raw natural materials (vegetables, fruits, grains, flour, etc.),
- 2) secondary products of food processing (soy okara, bran, etc.), and
- 3) preparations of dietary fibers (wheat fiber ‘Vitacel’ and ‘Jelucel’; soy fiber ‘Protocol’, citrus fiber ‘Citri-Fi’, potato fiber ‘Potex’ and ‘Lyckery’, etc.).

Applications for natural raw materials

Flours are included in this category. Flours are obtained from various natural raw materials. The effect of cereal and legume flour (wheat, barley, oat, rye, rice, corn, soy, chickpea and yellow lentil flour) on the physical, chemical, and sensory properties of beef patties has been determined. Cereal and legume flour increased yield, moisture, and fat retention and limits diameter reduction values. Oat flour increased moisture retention, texture, flavor and overall acceptability values of the cooked beef patties. Enriching minced meat with oat flour was found to increase fat and moisture retention but significantly change the cooking properties of patties. It, however, did not negatively affect organoleptic properties. This addition has also economic repercussions as it increases the profitability when selling burgers (Serdaroglu, 2006). Among the legume flours, chickpea flour had higher performance on the sensorial properties of beef patties (Kurt & Kiliççeker, 2012). The addition of chia flour as chicken skin substitute (15%) allowed to produce chicken nuggets with ‘high fiber content’ (Barrosa et al., 2018). Others have noted that the inclusion of 10% chia flour and olive oil in sausages allowed to increase the total amount of dietary fiber (98% IDF) (Pintado et al., 2016).

Vegetable fibers can be an attractive option to enrich certain meat products. These dietary fibers can be used as fat substitute and they tend to be used as additives to enhance the texture (juiciness, and tenderness) of certain types of meat products. Despite the fact that vegetables and fruits are a good source of dietary fiber, using them in raw form for enrichment of meat products is inefficient. This is because they contain a large amount of moisture, which can adversely affect the functional and technological parameters. In this case, the quantity of introduced dietary fiber has to be kept to a very small proportion. Alternatively, a larger portion of dried fruit and vegetables can be used.

Table 1. Dietary fibers and their technological properties in meat products

| Fiber sources | Dietary fiber components | Functional properties | Technological effect in the meat product | Reference |
|--|--|---|--|--|
| Cereal grains and bran: wheat, ray, rice. By-products: hulls, husk. | Cellulose, hemicellulose | Water-holding and fat-holding capacity | Regulate the moisture content in the meat products and crystallization during freezing increase cooking yield and firmness; substitute fat in chicken meatballs and beef patties | Talukder & Sharma, 2010; Gibis et al. 2015; Hu & Yu, 2015 |
| Fruits and vegetables. By-products: seeds of berries and fruits; apple, pear, tomato pomace; citrus peel | Cellulose, hemicellulose, pectin | Water-holding capacity, viscosity, gel-forming ability due to the high content of polyphenols, it exhibits antioxidant properties | Modify moisture, texture and color brightness of meat products. Improve emulsion stability and cooking yield, increase shelf-life, prevent lipid oxidation of chicken product | Turksoy & Ozkaya, 2011; Cava et al., 2012 |
| Oats, barley grains, bran and flour | Beta-glucan, cellulose, hemicellulose | Viscosity, Water-holding and Fat-holding capacity | Decrease cooking losses and reduce fat content improve the flavor, texture, and palatability of beef and pork patties, sausages, and meatballs | Yilmaz & Daglioglu, 2003; Serdaroglu, 2006; Choi et al., 2011; Schmiele et al., 2015 |
| Legumes: soybeans, beans, peas flour | Resistant starch, cellulose, hemicellulose | Water-holding capacity, Gel-forming ability | Reduce fat content, increase cooking yield and protein content. Improve emulsion stability, minimize the production cost of bologna sausage and chicken nuggets | Serdaroglu, 2006; Pietrasik & Janz, 2010 |
| Chicory root, Jerusalem artichoke | Inulin, fructooligosaccharides, cellulose, hemicellulose | Water-holding capacity, gel-forming ability | Substitute fat in low-fat meat products. Promote the development of acceptable color as well as textural and sensory properties of meat products | Sun et al., 2010; Tomaschunas et al., 2013; Afoakwah et al., 2015 |

Table 1 (continued)

| | | | | |
|---|------------------------------|--|---|--|
| Gum guar, gum arabic, algae, agar, alginates | Gums, carageenans, alginates | Viscosity, water-holding capacity, fat-binding capacity | Replace some portion of fat in meat products. Provide stability of emulsion, and gel texture improve cooking yield, texture and water retention in the sausages and frankfurters improve cooking characteristics and decrease mass transfer and diameter reduction, provide high yield, improves the thickness of products extend the shelf-life of minced pork patties | Beriain et al., 2011; Moroney et al., 2013 |
| Fungi and shellfish, shells of marine crustaceans | Chitin/chitosan | Gel-forming ability, high viscosity, water-holding capacity. | Stabilize the structure of meat products that leads to minimized shrinkage and improved product density improve stability of the meat emulsion | Cheung, 2013 |

Aloe vera is one of the interesting sources of natural dietary fiber that can be used in the technology of meat products. The results of studies on beef burgers with added Aloe vera, as well as goat meat nuggets with fresh Aloe vera gel, shown that it could be used to improve the quality of meat products. The authors noted 2.5% of Aloe vera, lead to an improved cooking yield of goat meat nuggets (Soltanizadeh & Ghiasi-Esfahani, 2015; Rajkumar et al., 2016).

The interesting source of dietary fiber is jabuticaba skin flour, obtained from jabuticaba fruit planting in Brazil. Alves et al. (2017) determined that the restructured hams with addition of 0.5% jabuticaba skin flour had virtually no changes in the physicochemical properties, except for the increase of fiber, phenolic compounds and hardness and reduced brightness.

Applications for secondary food processing additives

Bran is an example of secondary processing additive. As a source of dietary fibers in chicken patties, Talukder & Sharma (2010) found that oat bran contains more SDF than wheat bran. They also found that IDF were higher in wheat bran. The addition of bran resulted in an increase in water holding capacity and emulsion stability, as well as a significant increase in yield. The authors recommended the introduction of 10% oat and 15% wheat bran in chicken patties (Talukder & Sharma, 2010). In the studies of Choi et al. (2015), fat was partially replaced with rice bran fiber in sausages. The authors have measured the chemical, textural and sensory properties of these lower fat sausages. It was determined that the addition of rice bran fibers (2%) improved the taste while not significantly affecting textural attributes and it allowed to reduce the fat content by 12 to 30%. In Yılmaz studies (2004) rye bran was used in various amounts (between 5 and 20%) to replace fat in meatballs. The product saw an increase in its nutritional value and a decrease in its total content of trans-fatty acids. Thus, the authors concluded that rye bran can be used as a source of dietary fiber in meat products.

The processing of large quantities of vegetables and fruits generally produces by-products that are rich in dietary fibers. This wide spread and low cost raw material can be used as dietary fibers by the industry (Seo & Kyung, 2015). By-products of citrus, such as lemon albedo and orange fiber powder was added in various concentrations to cooked and dried sausages (Fernández-López et al., 2004). The authors determined that the addition of lemon albedo in an amount of 2.5% to 7.5% did not worse the organoleptic properties of sausages.

Okara is a by-product of the soy and tofu industries (Turhan et al., 2009). It is used in the production of beef patties in raw (Turhan et al., 2007) and in dried form (Turhan et al., 2009). The authors recommend adding no more than 7.5% of raw okara and not more than 22.5% of dry okara (Turhan et al., 2007; Turhan et al., 2009) in beef patties.

Applications of preparations of dietary fiber additives

Oat, rice and rye fibers are used by the food industry to enrich certain types of meat products. These types of dietary fibers tend to provide good water absorption capacity, they can enhance taste and they can offer an economical advantage as they are less costly than meat.

High absorption or bleached oats fibers have been added to determine their effects on quality characteristics of light bologna and fat-free frankfurters (Steenblock et al., 2001). The results showed that the addition of both types of oat fibers produces higher

yields but, in the sausages, oat bran fibers produced a harder product (high shear stress) and contributed to the production of sausages containing less humidity. High absorption and bleached oats fibers appear to produce different textures depending on the product in which they are used (Steenblock et al., 2001).

Jongaroontaprangsee et al. (2007), and Nilnakara et al. (2009) have obtained fibers from the outer leaves of cabbage and Seo & Kyung (2015) produced dietary fibers from Chinese cabbage waste. From these studies, it was determined that the powder from cabbage outer leaves possessed high water-holding and swelling capacities, indicating potential for use in many food applications (Jongaroontaprangsee et al., 2007). In addition, Seo & Kyung (2015) noted that dietary fibers derived from Chinese cabbage waste have probiotic, hypoglycemic and hypolipidemic effects.

Potato, cactus pear and pineapple fibers were also tested to improve meat products. The addition of dietary fiber from dry potato pulp, Potex and enzymatically extracted non-starch polysaccharides in pâtés allowed not only to reduce the content of animal fat, but also to improve the texture of the product. Diaz-Vela et al. (2017) used cactus pear and pineapple fibers as a source of dietary fibers in boiled sausages.

Soy fibers are used in meat products to increase yields because of their high water- and fat-holding capacities. Soy fibers are used to improve the structure of the sausage (Cofrades et al., 2008). In minced meat, the introduction of a soy fiber ‘Protocol’ allows to condense the structure of the finished product by creating a ‘three-dimensional skeleton’. This is particularly useful when low grade raw materials are used.

Inulin is a SDF which can be used as a fat substitute in meat products. For example, Mendoza et al. (2001) conducted a study using dry fermented sausages with a fat content close to 50 and 25% of the original amount by adding 7.5 and 12.5% of inulin, respectively. The results showed that the dry fermented sausages obtained had technological properties similar to conventional sausages, while they had a softer texture and tenderness, springiness and adhesiveness. The low-calorie dry-fermented sausages are currently available on the market and they contain approximately 10% inulin (Mendoza et al., 2001).

Pea fibers (obtained from the inner cell wall of yellow peas) contain about 48% fat, 44% starch, and 7% protein. This additive was added to beef patties, in a dry form. The aim was to lower fat by 10% to 14%. The recipe lead to an improvement of the tenderness and increased the yield with no detriment on juiciness and flavor (Anderson & Berry, 2000).

Lopez-Marcos et al (2015) obtained dietary fibers from different agro-industrial co-products. These included lemon dietary fibers, grapefruit dietary fibers, pomegranate dietary fiber, lemon albedo dietary fiber, and tiger nut fiber. Studies conducted using the obtained products showed that the emulsifying capacity and emulsion stability was generally high. On that basis, the authors suggest the possibility of using such types of dietary fibers in products that require emulsifiers and have a long shelf life (as they require long-term stability). The authors determined that lemon dietary fibers and grapefruit dietary fibers samples, with the highest soluble dietary fiber content, showed higher water holding capacity values than tiger nut fiber samples (with the lowest soluble dietary fiber content). In addition, the highest fat / oil binding values were obtained for lemon dietary fibers and lemon albedo dietary fiber samples, suggesting that the higher the ratio of the soluble dietary fiber / insoluble dietary fiber, the higher the fat / oil binding capacity. The authors also indicated that these fibers have the potential to reduce the adsorption of cholesterol (Lopez-Marcos et al., 2015).

Garcia and others (2002) conducted studies on reduced-fat dry-fermented sausages prepared with the addition of 1.5 and 3% cereal (wheat and oat) and fruit (peach, apple, and orange) fibers (García et al., 2002). The authors noted that the best sensory characteristics were obtained in sausages with the introduction of 1.5% fiber, especially orange fibers. In this case, it was found that a higher amount of fibers worsened the texture (Fernandez-Gines et al., 2005).

The sections above provided examples of how materials containing fibers can affect physical properties of meat products. Data reported in the literature on the effect of dietary fibers in various meat products with an indication of the established optimal dosages are summarized in Table 2.

Using combinations of dietary fibers in the formulation of meat products

Recently, a number of studies have been conducted on the usage of combinations of various types of dietary fiber in meat products. For example, Petridis et al. (2014) studied the cumulative synergistic effects of citrus fiber, rice bran and collagen on the texture and selected sensory characteristics of frankfurter-type sausages. An emulsion from pork skin has been used as a source of collagen. The most acceptable formulations were with 13% of collagen addition, 1.5% of citrus fiber and 0.5% of rice bran or 13% of collagen addition with 2% of citrus fiber. The authors mentioned that, for both formulations low fattiness and brittleness were achieved while a moderate elasticity was obtained. Using both formulations, sausages were adequately hard and cohesive and differed solely in color intensity (moderate vs light reddish) (Petridis et al., 2014).

Kılınççeker & Kurt (2018) studied the effects of inulin, carrot, and cellulose fiber additions on chicken meatballs. The authors noted that the use of fibers in meatballs can boost product quality and improve color properties (L, a, b values). Cellulose and carrot fibers augmented the yield and moisture absorption values while preventing diameter reduction of the fried samples.

Combinations of different types of fibers additives as part of meat formulations are currently being studied. It follows that we will be seeing more of these types of products in the market place.

Various non-traditional dietary fibers are used in other food products. Their high functional and technological potential show great promise for their integration in meat product formulations.

CONCLUSION

Although existing definitions of dietary fibers have common concepts and elements, no consensus has been reached to date. This may be due to the diversity of dietary fibers, the multiplicity of forms in which they may be available and, therefore, the complexity of possible physical and chemical interactions that may be taking place within the gastro-intestinal tract. The modern classification systems for dietary fibers reflect this. It is wide and diverse and can be based, for example, on origin, structure, solubility or physiological effect. Numerous positive physiological effects of the use of dietary fibers have been documented. These include curative and preventive effects for diseases or conditions such as obesity, certain types of cancers, cardiovascular diseases, diabetes, and constipation. Research on various types of dietary fibers continues to contribute new data on the health benefit of dietary fibers.

Table 2. Effects of dosages of dietary fibers on the properties of various meat products

| Groups | Source of fibers | Meat product | % Recommended | Determined effect | References |
|---------------------------|-----------------------|----------------------|---------------|---|-------------------------|
| Natural product | Barley flour | Sausages | 3.9 to 6.9* | Increase water absorption index and viscosities, reduce fat content | Choi et al., 2011 |
| | Chia flour | Chicken nuggets | 10 | Decrease the moisture, saturated fatty acids and monounsaturated fatty acids contents; lower the acceptability of the meat product | Barrosa et al., 2018 |
| | | Sausages | 10 | Increase the total amount of dietary fiber | Pintado et al., 2016 |
| | Oat flour | Beef patties | 4.0 | Increase the juiciness scores, no effect on other sensory properties, improve the cooking characteristics | Serdaroglu, 2006 |
| | | | 5.0 | Increase moisture retention, odor, texture, flavor and overall acceptability values | Kurt & Kiliççeker, 2012 |
| | Legume flour | Beef patties | 5.0 | Increase yield, moisture, and fat retention and decrease diameter reduction values | |
| | Aloe vera gel | Goat meat nuggets | up to 2.5 | Decrease ph value and protein content; reduce the lipid oxidation and microbial growth during storage | Rajkumar et al., 2016 |
| Secondary food processing | Jaboticaba skin flour | Restructured hams | 0.5 | Higher contents of phenolic compounds; greater weight loss; a darker shade; texture profile with smaller parameters of stiffness, cohesiveness, adhesiveness, flexibility and chewiness | Alves et al., 2017 |
| | Rye bran | Meatballs | 20 | Reduce total trans fatty acid, increase ratio of total unsaturated fatty acids to total saturated fatty acids, reduce weight losses, improve nutritional value, health benefits and color | Yilmaz, 2004 |
| | Chickpea hull flour | Chicken nuggets | 5 | Decrease in total cholesterol and glycolipid content, reduce sensory scores | Verma et al., 2012 |
| | Rice bran | Frankfurters | 2 | Reduce the moisture, ash, carbohydrate, energy value, cooking loss, and total expressible fluid, improve flavor and overall acceptability | Choi et al., 2015 |
| | Wheat bran | Chicken meat patties | 15 | Increase the water holding capacity and emulsion stability; increase in cooking yield, firmness, reduction in sensory attributes, moisture, protein, fat and cholesterol content. | Talukder & Sharma, 2010 |
| | Oat bran | | 10 | | |
| | Okara powder | Beef patties | up to 7.5 | Reduce the cholesterol content, increased the energy values; improve whc, cook loss and shrinkage, increase the ph, lightness and yellowness values | Turhan et al., 2009 |

Table 2 (continued)

| | | | | | |
|--------------------------------|-----------------------------------|-----------------------------|--------|--|----------------------------|
| Preparations of dietary fibers | Oat fiber | Light bologna, frankfurters | 3 | Increase yields and hardness and contribute to lighter red color | Steenblock et al., 2001 |
| | Fruit (orange) fiber | Dry fermented sausages | 1.5 | Reduce energy value; reduce fat without loss of sensory quality | García et al., 2002 |
| | Inulin | Emulsion type sausages | 6 | Reduce fat, energy content and color measurement; sensory evaluation comparable to the traditional product | Berizi et al., 2017 |
| | | Fermented sausages | 10 | Reduce calorie, improve softness, tenderness, springiness, and adhesiveness | Mendoza et al., 2001 |
| | Bacterial cellulose (Nata) | Chinese-style meatball | 10 | Acceptable textural and sensory qualities, decrease in cohesiveness value | Lin & Lin, 2004 |
| | Soy fiber | Bologna sausages | 2.5 | Improve fat and water binding properties, reduce fat, decrease textural properties and increase weight loss | Cofrades et al., 2008 |
| | Guar gum, xanthan gum, gum Arabic | Fried beef patties | 1.5 | Effect on yield and diameter reduction; increase the moisture retention; gum arabic increase lightness and yellowness values | Kilincceker & Yilmaz, 2016 |
| | Microcrystal-line cellulose | Beef patties | 2.0 | Decrease moisture loss; improve the texture in the sensory evaluation had more juiciness than the control and had a fat-like mouthfeel | Gibis et al., 2015 |
| Combined | Citrus fiber | Frankfurter sausages | 1.5 | Positive effect on the acceptability of the samples. Adequately hard and cohesive, differing solely in the intensity of color (moderately and low reddish) | Petridis et al., 2014 |
| | rice bran | | 0.5 | | |
| | pork skin | | 13.0 | Improve color properties (lightness, yellowness values), improve the technological properties | Kılınççeker & Kurt, 2018 |
| | Inulin, | Chicken meatballs | 3 | | |
| | carrot fibres | | 9 | | |
| | cellulose fibres | | 6 or 9 | | |

*for different fraction.

In recent years, more and more sources of dietary fibers have been discovered and tested. In this review, the information relevant to meat products was gathered. Traditional sources of dietary fibers added to meat products include cereals, vegetables and fruits. Non-traditional sources of dietary fibers include fungi, and secondary products of animal processing. Fibers can be used in raw and processed forms. Formulations now comprise combinations of dietary fibers.

All classes of dietary fibers can be used in the fabrication of healthy meat products (usually with lower fat content). In most cases, formulations can be adjusted such that additional sensory and functional-technological indicators (moisture binding, emulsifying ability, palatability, color) benefits can be offered. In some cases, the taste can also be improved.

Consumers recognize that their health can be improved through diet and this review showed that, as results, there is a trend for an increasing use of products containing dietary fibers amongst consumers. In fact, at the moment, the use of dietary fiber in the production of meat products is becoming widespread. It follows that manufacturers are looking to improve the functional and technological properties of their products. Meat manufacturers are also interested in increasing the yield of their products. With both consumers and manufacturers engaged, the use of dietary fiber will no doubt contribute to improving the health of the population. It will also contribute to the enhancement of functional properties of many meat products while promoting the usage of available raw materials from other food industry sectors.

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